CHAPTER 4

BASIC DESIGN CONSIDERATIONS

4-1. General. The required treatment is determined by the influent characteristics, the effluent requirements, and the treatment processes that produce an acceptable effluent. Influent characteristics are determined by laboratory testing of samples from the waste stream or from a similar waste stream, or are predicted on the basis of standard waste streams. Effluent quality requirements are set by Federal, interstate, state, and local regulatory agencies.

4-2. Period of design. The service life for wastewater treatment works at mobilization facilities will be 5 years. Design of wastewater treatment facilities must account for all current flows as well as anticipated flows occurring during this service period.

4-3. Estimating service demand.

a. Population data. Army installation populations are controlled according to work assignment; therefore, this information can be obtained directly from personnel records and requirement projections.

b. Hydraulic loadings. The hydraulic waste loads to be used for resident personnel is 100 gpcd. The hydraulic waste load to be used for nonresident personnel is 30 gpcd.

c. Organic loadings. The organic waste loads to be used for resident personnel are given in table 4-1. The values shown in table 4-1 for that portion of the contributing population served by garbage grinders will be increased by 65 percent for BOD values and 100 percent for suspended solids. Contributing compatible industrial or commercial flow must be evaluated for waste loading on a case-by-case basis.

Table 4-1. Sewage Characteristics

Item	Resident Personnel pounds/capita for 24 hours	Nonresident Personnel pounds/capita for 8-hour shift
Suspended Solids	0.20	0.10
Biochemical Oxygen Demand	0.20	0.10

d. Population equivalents. Suspended solids and organic loading can be interpreted as population equivalents when population data constitute the main basis of design. Typical population equivalents applicable to Army facilities were given in table 4-1. These equivalent values can also be used to convert nondomestic waste loads into population design values.

e. Capacity factor. A capacity factor is used to make allowances for population variation, changes in sewage characteristics, and unusual peak flows. The design population is arrived at by multiplying the actual authorized Army and civilian personnel population by the appropriate capacity factor. Total personnel is the sum of resident personnel plus one-third the nonresident personnel. For a resident population of 10,000 and nonresident population of 3,000 persons, total personnel would equal 11,000 (= 10,000 + 3,000/3), capacity factor would be 1.25, and design population would be 13,750 (= 11,000 x 1.25). Capacity factors for various levels of actual total personnel are given in table 4-2.

Table 4-2. Capacity Factors

Total Personnel	Capacity Factor
5,000 or less	1.50
10,000	1.25
20,000	1.15
30,000	1.10
40,000	1.05
50,000 or more	1.00

4-4. Volume of wastewater.

a. Variations in wastewater flow. The rates of sewage flow at Army installations vary widely throughout the day. The design of process elements in a sewage treatment plant is based on the average hourly rate of flow. Transmission elements, such as conduits, siphons, and distributor mechanisms, will be designed on the basis of an expected peak rate of flow of three times the average rate. Consideration of the minimum rate of flow is necessary in the design of certain elements, such as measuring devices and dosing equipment. For this purpose, 40 percent of the average flow rate will be used.

b. Average wastewater flow. The average wastewater flow to be used in the design of new treatment plants will be computed by multiplying the total tributary population by the per capita rates of flow determined from 4-3.b. (applying the appropriate capacity factor from table 4-2), and then adjusting for such factors as industrial wastewater flow, storm water flow, and infiltration. Where shift personnel are engaged, the flow will be computed for the shift when most of the people are engaged. Good practice requires exclusion of storm water from the sanitary sewage system to the maximum practical extent. Infiltration must also be kept to a minimum. Both must be carefully analyzed, and the most realistic practical quantity that can be used in design must be assigned to these flows. Average wastewater flow is usually expressed in mgd, but will be calculated to the appropriate units for design of the unit process under consideration.

c. Industrial flow. Industrial wastewater flows will be minimal at most Army installations. When industrial flows are present, however, survey measurement is the best way to ascertain flow rates. Modes of occurrence (continuous or intermittent) and period of discharge must also be known.

d. Storm water flow. Storm water flows are significant in treatment plant design only when combined sewer systems are served. Combined sewer systems will not be permitted in new Army installations. Separate sewers are required, and only sanitary flows are to be routed through treatment plants.

e. Ground water infiltration. In calculating wastewater volumes for new facilities, allowance must be made for infiltration as given in EM 1110-3-174.

4-5. Wastewater characteristics.

a. Normal sewage. For treatment facilities for new installations that will generate no unusual waste, the treatment will be for normal domestic waste with the following analysis:

pH	Normal (7.0)
Total solids	720 mg/l
Total volatile solids	420 mg/l
Suspended solids	200 mg/l
Settleable solids (ml per liter)	4 ml/l
BOD	200 mg/l
Total nitrogen	30 mg/l
Ammonia nitrogen	15 mg/l
Oils and grease	100 mg/l
Phosphorus	10 mg/l
Chloride	50 mg/l

When the water supply analysis for the installation is known, the above analysis will be modified to reflect the normal changes to constituents in water as it arrives at the wastewater treatment plant. Changes will be as follows:

P in water supply + 12 mg/l = P in plant influent

Cl in water supply + 8 mg/l = Cl in plant influent

Total nitrogen in water supply + 12 mg/l = Total nitrogen in plant influent

b. Nondomestic loading. Nondomestic wastes are storm water, infiltration, and industrial contributions to sewage flows. Storm water and infiltration waste loadings can be determined by the analyses of normal sewage as presented in the previous section. For these types of flows, the major loading factors are suspended solids, BOD, and coliform bacteria. Industrial waste loadings can also be characterized to a large extent by normal sewage analyses. However, industrial waste contains contaminants not generally found in domestic sewage and is much more variable than domestic sewage. This is evident in terms of pH, BOD, COD, grease and oils, and suspended solids; other analyses (e.g., heavy metals, thermal loading, and dissolved chemicals) may also be necessary to characterize an industrial waste fully. Each industrial wastewater must be characterized individually to determine any and all effects on treatment processes.

4-6. Plant site preparation. Site drainage is an important factor in design of wastewater treatment facilities. Capacities of drainage structures will be designed in accordance with requirements of EM 1110-3-136. All treatment units must be protected from surface wash by proper shielding and drainage.

4-7. Plant layout.

a. Arrangement of treatment units. The first step in determining the best arrangement of units is to arrange all units sequentially according to the flow of wastewater through the system. The resulting hydraulic profile for wastewater flow will determine the relative vertical alinement of each of the plant's units. Final arrangement of the units then results from adaptation of site features to the treatment plant's functional and hydraulic requirements. Allowance must also be made for the area of operation and maintenance of the treatment units. If sufficient head is available for gravity flow, the hydraulic requirements will control the plant layout. Greater flexibility in arranging the treatment plant units is achieved with intermediate pumping of wastewater, although pumping should be eliminated wherever possible. The treatment plant must operate during emergency conditions such as power failures, and also during periods of maintenance work on treatment units. Dual units should be provided in all feasible cases to provide operational reliability and flexibility.

b. Conduits and pipelines. Conduits and pipes will be arranged in such a manner as to reduce space and cost requirements. They will be designed to handle the expected maximum flows through the treatment plant.

c. Bypasses and overflows. Provisions for bypassing individual treatment units will be made so that each unit can be taken out of service without interrupting the plant operation. Bypasses will not be provided for screens, chlorination units, nor other unit processes where duplicate units are available. Overflows will be used to prevent hydraulic overloading of treatment units, especially biological treatment units. Return of flows not treated or alternate treatment must be provided.

d. Treatment plant discharge. Outfall sewers will be extended to the low-water level of the receiving body of water or to submergence required by regulatory authority to insure satisfactory dispersion of the plant effluent. Provisions for effluent sampling and monitoring are required. The design will assure the structural integrity of the outfall, prevent failure due to erosion, and prevent backflow during flooding.

4-8. Plant hydraulics.

a. Hydraulic loadings. The overall head allowances required for various types of wastewater treatment plants are as follows:

Type of Plant	Head Required feet
Primary treatment	3 to 6
Activated sludge	3 to 6
Trickling filters	
Low-rate	18 to 24
High-rate, single-stage	10 to 15

b. Limiting velocities. A minimum velocity of 2.0 fps at design average flow is required for channel flow. At minimum flows, a minimum velocity of 1.5 fps is required to prevent suspended solids from settling in flow channels.

c. Head loss. The total head loss through a treatment plant is the sum of head losses in the conveyance of wastewater between elements of the treatment process and the losses of head through treatment units. Head losses from wastewater conveyance are due to frictional losses in conduits, bends, and fittings, and allowances for free-fall surface and for future expansions. EM 1110-3-174 gives detailed guidance and charts for computing head losses in pipes and conduits. Head losses through process equipment are dependent on the specific units and are specified by their manufacturers or by the design engineer.

4-9. Plant auxiliary facilities.

a. General. A potable water supply will be provided. Sanitary facilities, toilet, shower, and lavatory with hot and cold water supply will be provided, except for installations with less than 0.1 mgd capacity. The potable water line will incorporate a backflow prevention device to prevent the contamination of the water supply. Emergency power for essential equipment will be provided. Adequate working and storage space is required for all plants. The general plant layout will facilitate operation and maintenance of the treatment units and their appurtenances.

b. Controls and monitoring. The plant arrangement will take into consideration the related control and monitoring requirements. Laboratory facilities will be provided either on or off site for conducting the necessary analytical testing for the purpose of process control and compliance with regulatory requirements.

4-10. Metering and instrumentation.

a. Continuous recording of flow. Wastewater flow rates will be monitored and recorded for purposes of evaluating treatment plant performance and will also be used when treatment charges are involved. Continuous flow measurement is necessary in order to monitor diurnal variations in flow which may affect treatment plant efficiency. Flow rates must also be taken into account when sampling wastewater quality.

b. Monitoring equipment for process control. Monitoring equipment will be used to indicate and/or record flow quantities and, if justified, pressure, temperature, liquid levels, velocities, and various quality parameters.

(1) Monitoring at pumping stations. In sewage pumping stations, flow measurement is necessary to control periodic pump operation. Watt-hour meters and pump time meters will be used to insure balanced pump usage among all units in multiple-pump installations.

(2) Monitoring of biological treatment. Trickling filter monitoring will include flow measurement of influent, effluent, and recirculation lines, and also volume of sludge pumped to or from the digesters. These parameters are used in determining and controlling hydraulic and organic loading as well as in controlling settling tank efficiencies. Activated sludge treatment will require the same monitoring with the addition of MLVSS and air-supply monitoring.

4-11. Sampling. Wastewater sampling at various points in the sewage treatment process is useful in evaluating operation efficiency. This can be used internally in order to optimize the process and is also used by regulatory agencies to judge whether treatment plant regulations are satisfied. Sampling is also used to establish changes when treating industrial wastes. Provisions for sampling sites must be made in the plant design. The type of sampling provisions, composite or grab sample collection, will be dictated by the type of sampling required in the National Pollutant Discharge Elimination System (NPDES) discharge permit. Forward flow, recycled flow, sludge flow, chlorine residual, pH, and dissolved oxygen are some of the process control parameters that can be monitored on a continuous basis.

4-12. Standard drawings. Standard drawings have been prepared for the recommended treatment schemes outlined in chapter 5. These drawings may be altered depending on local conditions and criteria.